

Bailey, Martha B. (MSFC-NAS802002)[MAINTHIA]

From: Carrasquillo, Robyn L. (MSFC-EI01)

Sent: Wednesday, October 31, 2007 3:41 PM

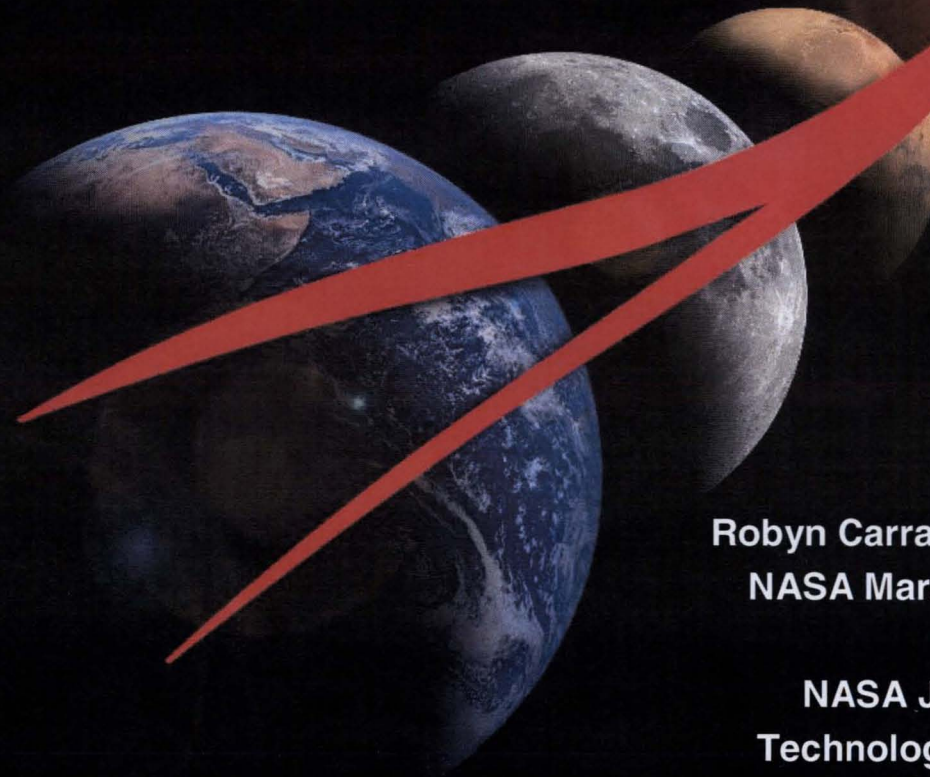
To: Bailey, Martha B. (MSFC-NAS802002)[MAINTHIA]

Subject: what it's about

The presentation is for the ECLSS session of the Constellation Technology Exchange Conference and is to describe what new technology challenges the Constellation mission presents for the ECLSS, in order to communicate these needs with industry.



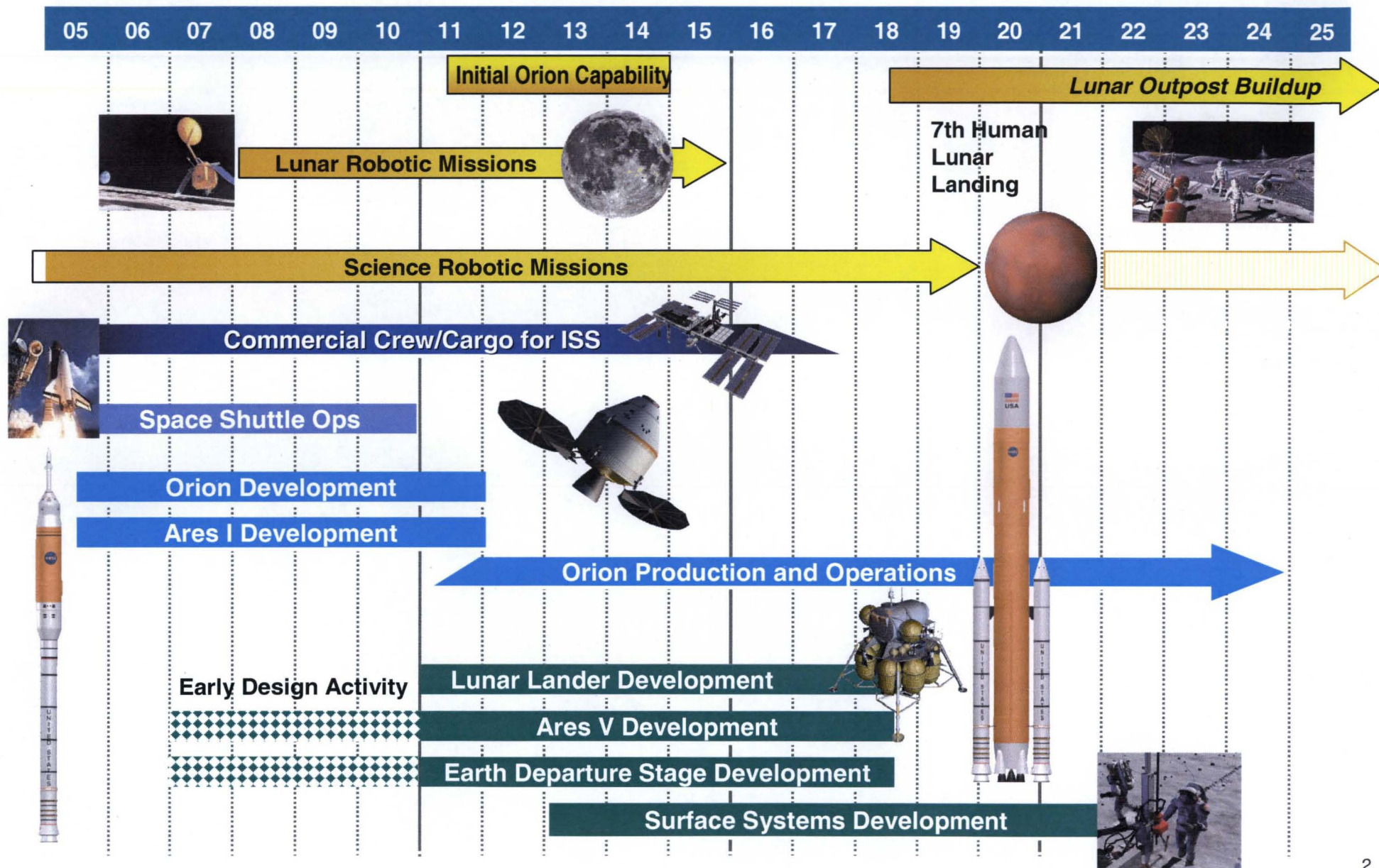
Life Support Technology Challenges for NASA's Constellation Program



Robyn Carrasquillo & Robert Bagdigian
NASA Marshall Space Flight Center
Michael Ewert
NASA Johnson Space Center
Technology Exchange Conference
Nov. 14-15, 2007

CONSTELLATION

NASA's Exploration Roadmap



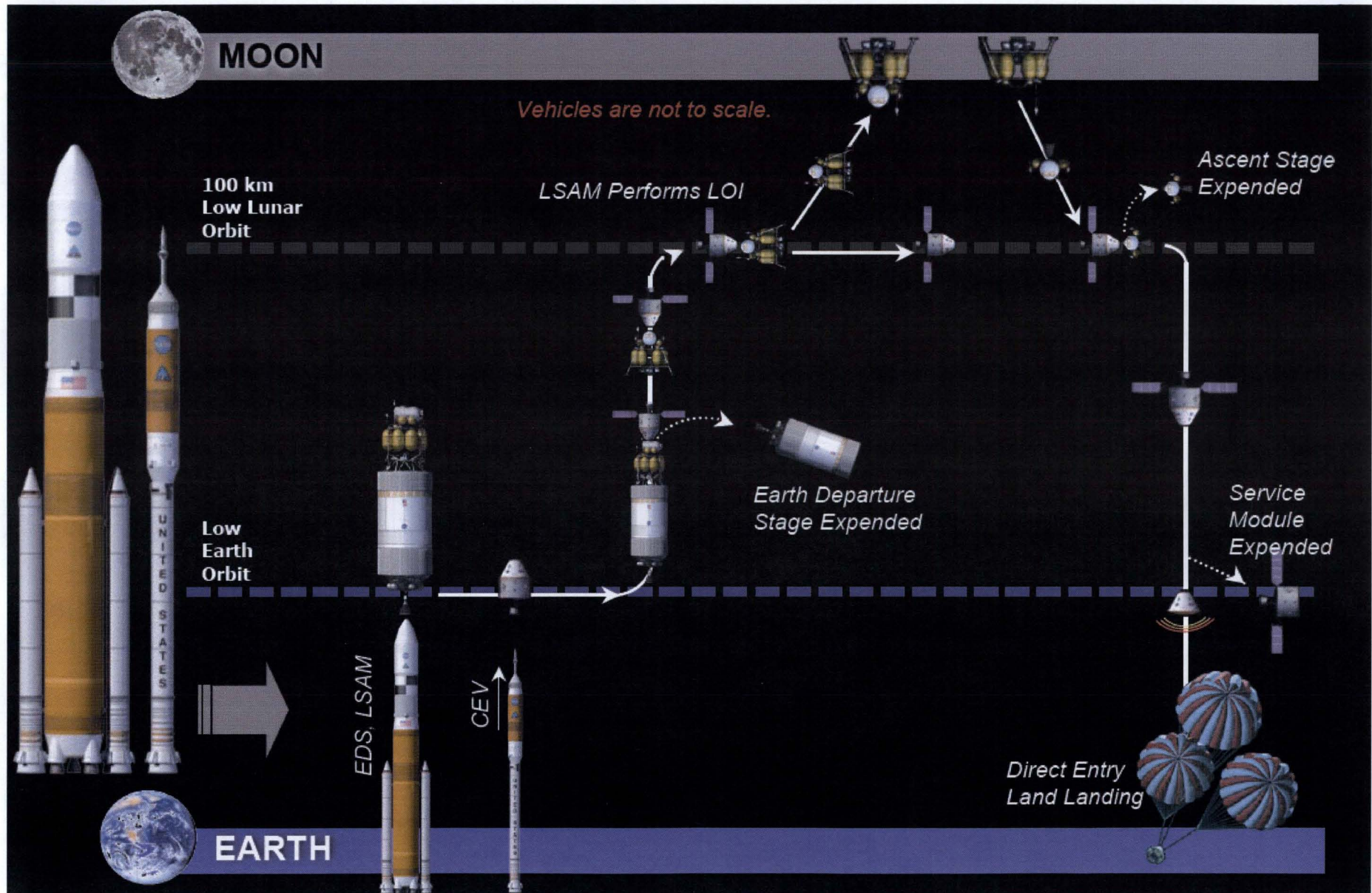
Overview of Mission Phases

- ◆ **ISS crew/cargo transfer**
- ◆ **Initial Lunar**
- ◆ **Lunar Outpost**
- ◆ **Mars Transit**
- ◆ **Mars Outpost**

ISS Mission

- ◆ Transport up to 6 crew members on Orion for crew rotation
- ◆ 210 day stay time
- ◆ Emergency lifeboat for entire ISS crew
- ◆ Deliver pressurized cargo for ISS resupply





Lunar Lander



- ◆ **Transports 4 crew to and from the surface**
 - Seven days on the surface
 - Lunar outpost crew rotation
- ◆ **Global access capability**
- ◆ **Anytime return to Earth**
- ◆ **Capability to land 20 metric tons of dedicated cargo**
- ◆ **Airlock for surface activities**
- ◆ **Descent stage:**
 - Liquid oxygen / liquid hydrogen propulsion
- ◆ **Ascent stage:**
 - Storable Propellants

Lunar Outpost

- ◆ **Located at South Pole**
- ◆ **Permanently manned**
- ◆ **Capability for daily EVA**
- ◆ **Use of ISRU**
- ◆ **Pressurized Rover**
- ◆ **Habitat supporting 4 crew**



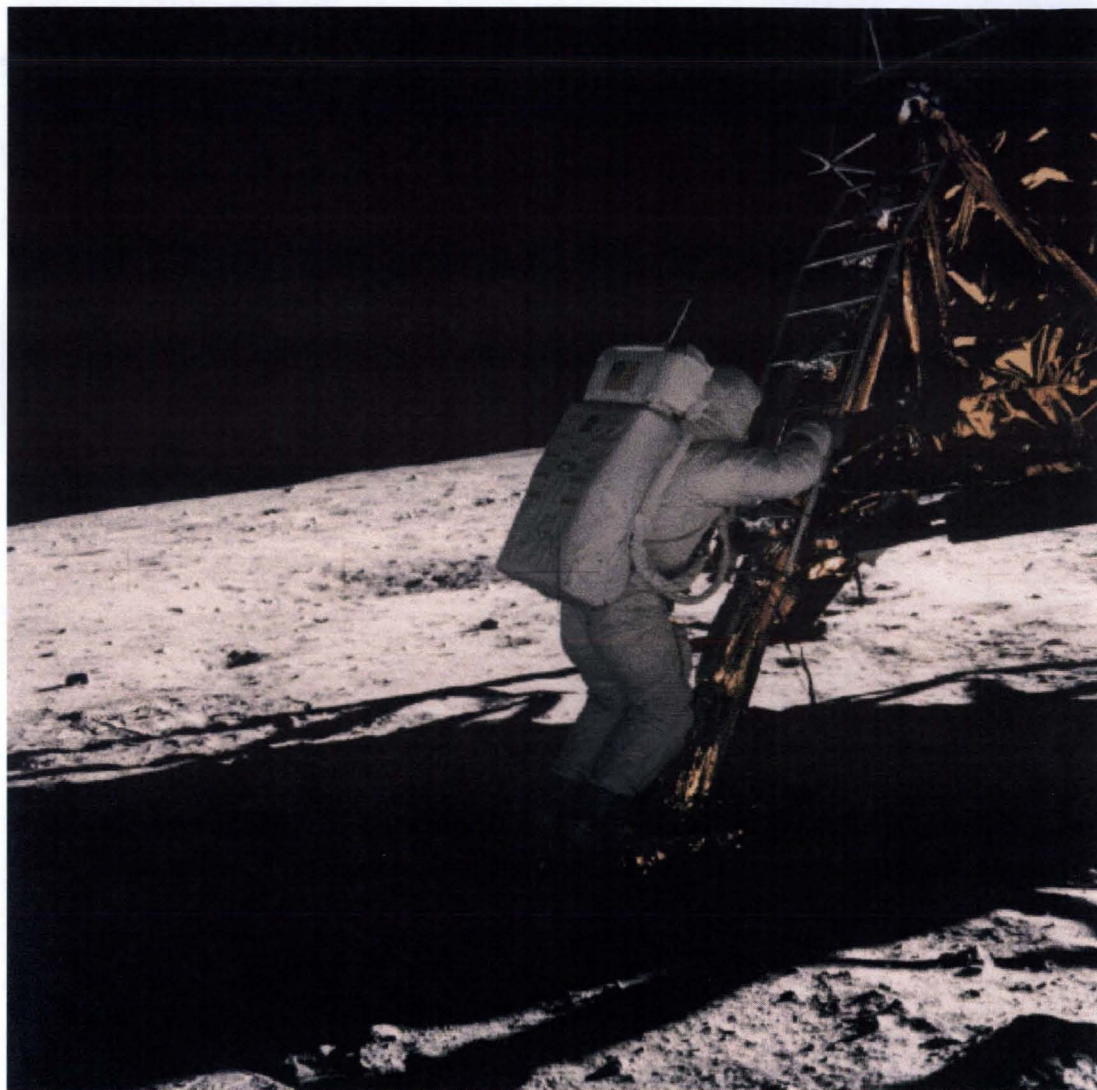
Unique New Requirements and Challenges

- ◆ **Carry up to 6 crew to the ISS**
 - Crew module must support 0-6 crew
- ◆ **Carry 4 crew to the moon**
 - Crew module must orbit moon unmanned for 6 months
- ◆ **Establish permanent Outpost at South Pole**
 - Cargo lander to leave Outpost building blocks behind
- ◆ **Outpost will have limited resupply capability**
 - Life Support loops must approach closure to minimize resupply needs
 - ~6 months resupply interval
- ◆ **Frequent Outpost EVA's**
 - EVA life support with inherent losses of vented CO₂ and water
- ◆ **Pressurized rover for extended duration EVA's**
- ◆ **132 hour unpressurized survival in Command Module**
 - Life support system must support crew whether in open cabin or suits
- ◆ **Lunar dust environment**
- ◆ **Anywhere access on moon for lunar sorties**

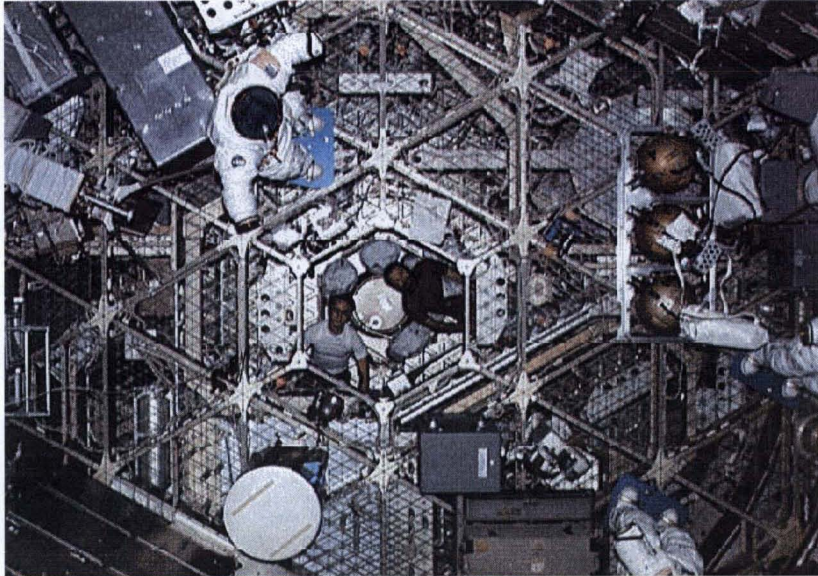
Historical U.S. Life Support Systems

◆ Apollo

- 3 crew
- 6 m³ habitable volume
- 6-12 day mission lengths
- Open loop expendable (LiOH) air revitalization system
- Overboard urine vent
- Rudimentary solid waste collection (bags)
- 100% oxygen environment at 5 psia
- Potable water from fuel cells
- Suit loop for emergency depress survival



Historical U.S. Life Support Systems



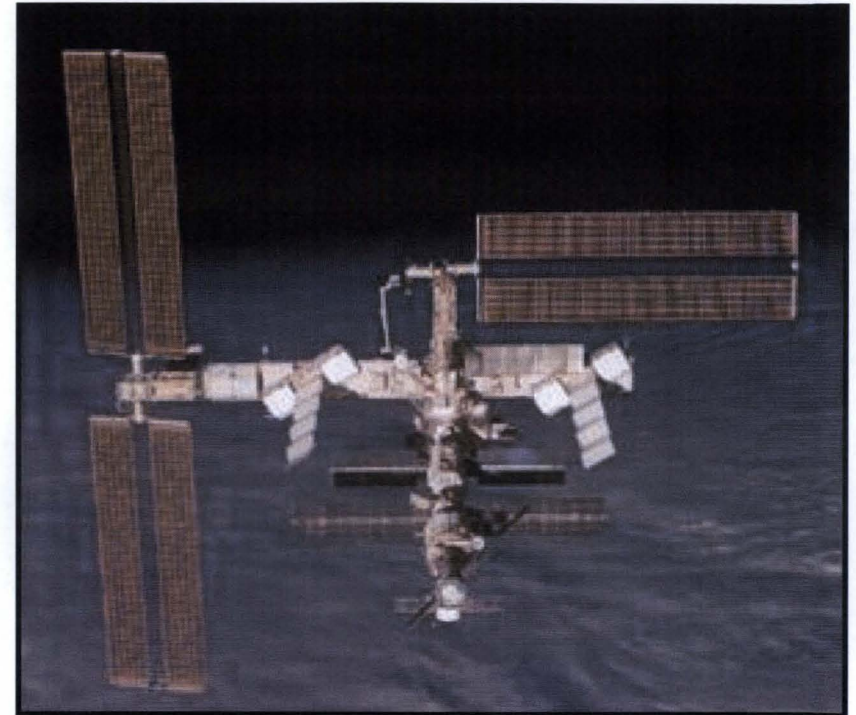
◆ Skylab

- 3-person laboratory
- 28-84 day missions
- 361 m³ total habitable volume
- Mixed O₂/N₂ atmosphere at 5 psia; 72% O₂/28% N₂
- 2-bed molecular sieve regenerable CO₂/humidity removal, desorbed to space. Activated charcoal for trace contaminant control during missions; venting of laboratory between missions avoided long-term contaminant buildup.
- Condensing heat exchanger for further humidity control
- Potable water launched with Orbital Workshop
- Disposable bag waste collection

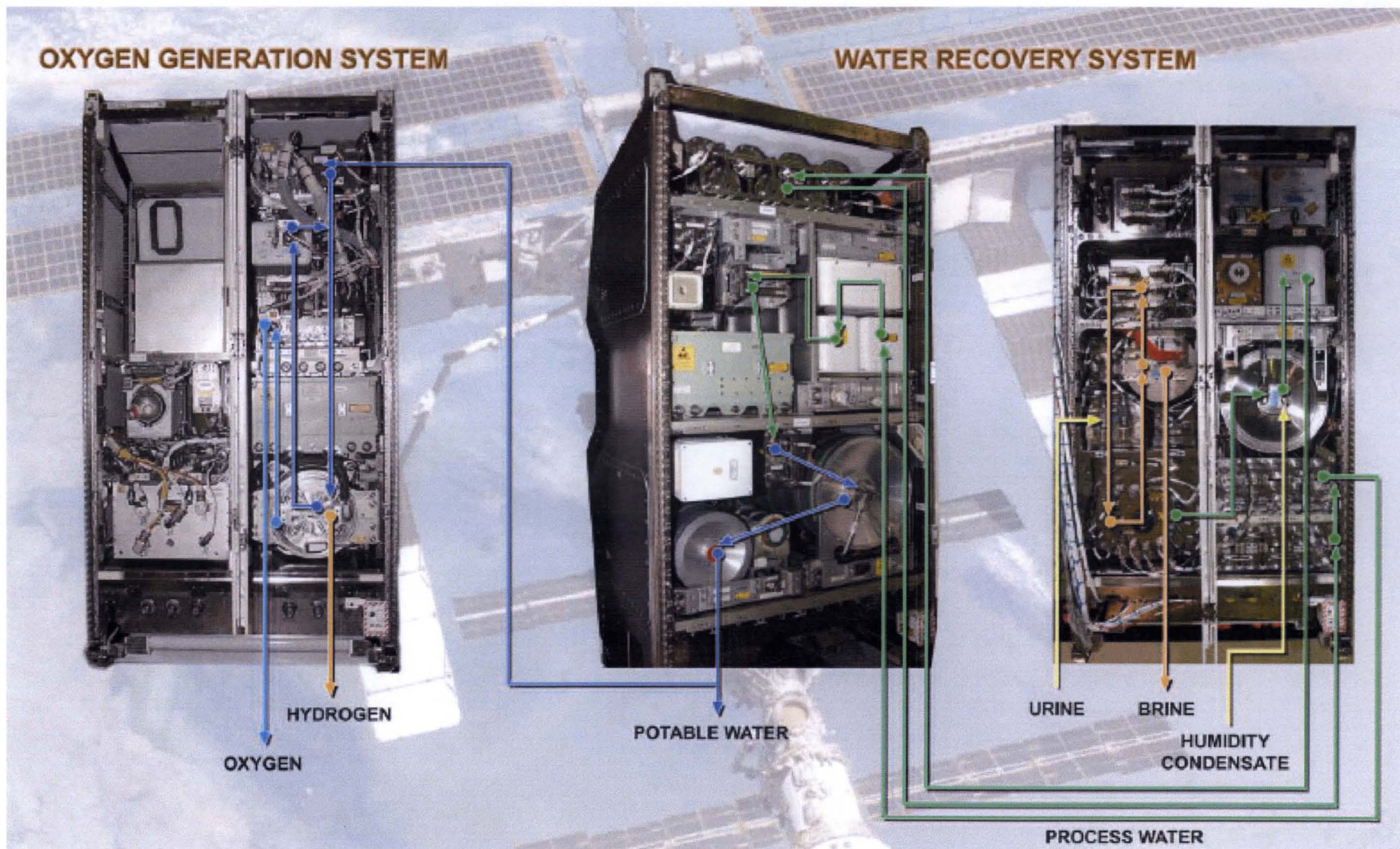


◆ International Space Station

- 3-person crew; to go to 6-crew with activation of Regenerative ECLSS
- Regenerative zeolite CO₂ removal, vented overboard
- Ambient pressure oxygen generation via water electrolysis
- Scar for CO₂ reduction (Sabatier)
- Expendable and catalytic oxidation trace contaminant control
- Urine and humidity condensate water processing (FY08)
 - Distillation, multifiltration, and catalytic oxidation
 - 93% recovery of wastewater to potable quality



ISS Regenerative ECLSS



Improvements Needed Over State of the Art Historical Systems – Short-Duration Vehicles

Atmosphere Revitalization

- ◆ **Regenerative open-loop atmosphere revitalization (CEV, lunar sortie lander, pressurized rover)**
 - CO₂ and humidity removal via vacuum swing adsorption eliminates need for condensing heat exchanger and expendable LiOH
 - Recovery of oxygen and water not critical for short-duration missions
 - Candidate technologies include amine and zeolite-based systems
- ◆ **Improved particulate filtration for lunar dust**
 - Filter particles to xxxx
- ◆ **Emergency breathing mask which does not increase cabin %O₂ to unsafe levels.**
 - Looking at adapting commercial chemical mask.
- ◆ **Targeted trace contaminant adsorbents**
 - Ammonia from amine and suit loop contingency
 - Alcohols typically removed by condensing heat exchanger
- ◆ **Deployable post-fire cleanup device (aka “smoke eater”)**

Improvements Needed Over State of the Art Historical Systems – Short-Duration Vehicles

Atmosphere Monitoring

- ◆ **Post-fire combustion products monitor**
- ◆ **Particulate monitor for lunar dust**
 - Monitor to xxxx

Improvements Needed Over State of the Art Historical Systems – Short-Duration Vehicles

Water Storage and Supply

◆ Biocide

- Compatible with materials
- Does not need to be removed for crew health
- Stable for 6 month durations

Waste Collection

◆ Improved urine pretreatment

- Low toxicity, non-corrosive
- Simple introduction method

◆ Solid waste containment that lends itself to transfer to Outpost for water recovery

◆ Simplified, no power, urine separator/vent that works with both genders

- Apollo “coke can” worked marginally well for males only.
- Needed as backup if spin separator fails

Lunar Surface ECLSS Functions

Pressure Control Subsystem

- O₂ Supply
- N₂ Supply
- Positive Pressure Relief
- Intermodule Pressure Equalization
- Cabin Depress
- Cabin Pressure Monitoring

Fire Detection & Suppression Subsystem

- Fire Detection
- Fire Suppression

Emergency Equipment

- O₂ Masks
- Toxic Masks

Air Revitalization Subsystem

- CO₂ Removal
- CO₂ Reduction
- O₂ Generation
- Temperature & Humidity Control
- Trace Contaminant Control
 - regenerative
 - non-regenerative (for module ingress)
- Ventilation
 - intramodule
 - intermodule
- Airborne Particulate Control
- Atmosphere Composition Monitoring
 - ppO₂
 - pp CO₂
 - pp H₂O (v)
 - Trace Contaminant

Water Recovery & Mgmt Subsystem

- H₂O Recovery
 - Humidity Condensate
 - Waste Hygiene
 - Urine
- Brine Recovery
- Water Storage & Distribution
- Water Quality Monitoring

Waste Mgmt Subsystem

- Waste Collection & Drying
- Trash Compaction & Drying

Improvements Needed Over State of the Art Historical Systems – Long-Duration Missions

Atmosphere Revitalization

◆ Atmosphere loop closure

- Improved CO₂ removal – more robust, lower power, integration with CO₂ reduction
 - Structured sorbents to preclude dust generation
 - Water separation which minimizes power/heat for regeneration
 - Mechanical or chemical adsorption-based CO₂ compression and storage
- CO₂ reduction
 - Sabatier only (50% oxygen recovery from CO₂)
 - Complete oxygen recovery from CO₂
 - Challenge is to minimize resupply of catalyst/expendables for this to trade positively over bringing additional water
 - Sabatier plus hydrogen recovery from methane
 - Bosch
- Recovery of EVA-generated CO₂ and H₂O
 - Frequent EVA's from Outpost will result in large losses of these resources with current technology

Improvements Needed Over State of the Art Historical Systems – Long-Duration Missions

Atmosphere Revitalization, cont.

- ◆ **High pressure oxygen generation for EVA and storage**
 - Possible synergy with Power fuel cells and ISRU
- ◆ **Potential need for improved hydrogen sensor**
 - Based on ultimate design of HPOGA and other hydrogen-containing systems (like Sabatier, fuel cells, etc).
- ◆ **Improved particulate filtration for lunar dust**
 - Specific application for outpost/airlock
 - Methods to prevent dust from entering airlock
 - Methods to remove dust from atmosphere
 - Robust seals, connectors
- ◆ **Improved Trace Contaminant catalysts, sorbents**
 - Reduce expendables
 - Lower catalytic oxidation temperature
 - Possible photocatalytic filtration of entire air stream to reduce contaminant load of condensate (currently performing trades)
 - Possible incorporation into integrated CO₂ removal/reduction system

Improvements Needed Over State of the Art Historical Systems – Long-Duration Missions

Atmosphere Monitoring

- ◆ **Post-fire cleanup monitor (combustion products) – same as short-duration mission need**
- ◆ **Particulate monitor for lunar dust – same as short-duration mission need**
- ◆ **Trace Contaminant Monitor**
 - Long-duration contaminant buildup concern, and inability to bring back samples for analysis
- ◆ **Microbial monitor**

Improvements Needed Over State of the Art Historical Systems – Long-Duration Missions

Water Processing

◆ Improved water recovery

- >94.5% water recovery from wastewater (primary processor)
- 100% water recovery from brine
- Decreased expendables – filters, absorption media
 - Current ISS water recovery system uses 8 lb resupply/100 lb water recovered including maintainable items (2.7 lb expendables/100 lb water recovered)
- Consider use of partial gravity to simplify planetary base system
 - Potential use of modular components that could be added to partial-g system to function in micro-g
- Improved urine pretreat (from short-duration vehicle list) is key to this effort as well.

◆ In-line TOC monitor

- For improved long-term process control and monitoring of water system

◆ Biocide monitor

Improvements Needed Over State of the Art Historical Systems – Long-Duration Missions

Waste Storage/Processing

- ◆ **Recovery of water from solid waste (metabolic and trash)**
 - Tentative target is 50% recovery of water from solid waste
 - Methods to avoid physical transfer of waste from collection container to processor
 - Possibly retrieve containers from Lander to recover resources
- ◆ **Stabilization and long-term storage of solid waste**
 - Could include waste compaction and drying

Improvements Needed Over State of the Art Historical Systems – Long-Duration Missions

Habitability Functions

◆ Laundry

- Very preliminary trades look favorable
- Includes need for soap development that is compatible with water processor and crewmembers